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by

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EFFICIENT LASER ACTION FROM TWO CW LASER PUMPED PYRROMETHENE-BF_2 COMPLEXES

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Two new pyrromethene-BF_2 dyes P-556 and P-567 were tested for cw laser operation. P-556 demonstrated a significant advance in the 530-620 nm region over commercially dyes currently available, where the best cw dyes in any range have peak efficiencies on the order of 35% and dyes in this range typically less then 25%. The P-556 had a cw efficiency of 45% at the peak.

Among lasers, cw dye lasers have found very wide applications as sources of broad tunable radiation. Using different laser dyes, one can cover the near UV to the near IR portion of the spectrum. Besides tunability, cw dye lasers can also provide high power outputs. However, a serious drawback of cw dye lasers, especially where high power outputs are required, is the high cost of the optical pump. In most cases, the pump source is either a cw ion argon or krypton laser [1].

Other than the construction of the cw dye laser itself, output powers critically depend on the power output of the cw pump source and on the laser dyes employed.

Therefore, a rather simple and inexpensive method to increase the power output of all cw dye lasers, may simply involve the replacement of presently used laser dyes with improved laser dyes. We define an improved laser dyes as a dye, which besides a high quantum fluoresce yield Q_F, has lower triplet-triplet absorption over the fluorescence spectral region when compared to conventional laser dyes.

Efficient laser action under flashlamp excitation has been obtained from some pyrromethene-BF_2 (P-BF_2) complexes [2-5]. We wanted to test their suitability for laser action under cw laser excitation.

The P-BF_2 complexes present a new class of laser dyes, their spectral region of laser action stretches from the green/yellow to the red portion of the spectrum. Like the xanthene (rhodamine) laser dyes, they posses high quantum fluorescence yields Q_F, which are generally in the 0.80 to 0.95 range.

Significantly, the triplet extinction coefficient $_T$ over the laser action spectral region of some of the P-BF_2 complexes is only about one fifth of the rhodamine laser dyes [5].

The dyes disodium 1,3,5,7,8-pentamethylpyrromethene-2,6-disulfonate-BF_2 complex (Exciton P-556) and 1,3,5,7,8-pentamethyl-2,6-diethylpyrromethene-BF_2 complex (Exciton P-567) were previously described [3,4]. These two dyes were tested under cw lasing conditions.

The test equipment employed was a cw argon ion laser (Spectra-Physics model 2080), a linear standing wave dye laser with a 300 uM jet (Spectra-Physics model 375B), and a water cooled circulator running at 120 PSI.

The P-556 dye was dissolved in pure ethylene glycol (EG) to concentrations of 0.5 to 2.0 x 10^{-3} Mole/L, with 1.5 x 10^{-3} Mole/L being the optimum. Because the absorption peak for P-556 is at 500 nm (Fig. 1), we used all-lines (457.9 to 511.5 nm) for excitation. With 5 Watts of pump power, the dye lased from 530 to 624 nm with a peak power of 2.25 Watts at 553 nm (Fig. 2). This represents a 45% efficiency as compared to typical values of <25% for Rhodamine 110 (Rh110) and Coumarin 6 (C6) the standard dyes in this wavelength range. Also, we belief 45% is one of the highest efficiencies of any cw dye reported in a commercial dye laser system. The half life of P-556 was measured to be 350 Watts/Hrs on a one time sample.

The P-567 dye was dissolved in a combination of n-methyl-2-pyrrolidinone (NMP) and propylene glycol monophenyl ether (PPH) to a concentration of 1.5 x 10^{-3} Mole/L. With 5 Watt all-lines

pump power, this dye lased from 552 to 608 nm with peak power of 1.8 Watts at 571 nm (Fig. 2). The half life for P-567 was measured to be 460 Watts/Hrs on one sample. However, the half life of this dye may have been limited by the solvent incompatibility used in the circulator.

Rhodamine 6G tested in the same laser produced 1.5 Watts for a 32% cw efficiency. It has a broader tuning range and a much longer half life.

In summary, of the two dyes tested, P-556 was far superior to other dyes, encompassing the dye P-567. Compared with currently available laser dyes like C6 and Rh110, P-556 had greater cw efficiency, was more readily dissolved in EG with no triplet quencher required, and had a half life that was over 3 times longer than C6 or Rh110.

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Figure 1

Absorption (S-S) spectrum of the pyrromethene-BF_2 complex P-556, dissolved in ethylene glycol.

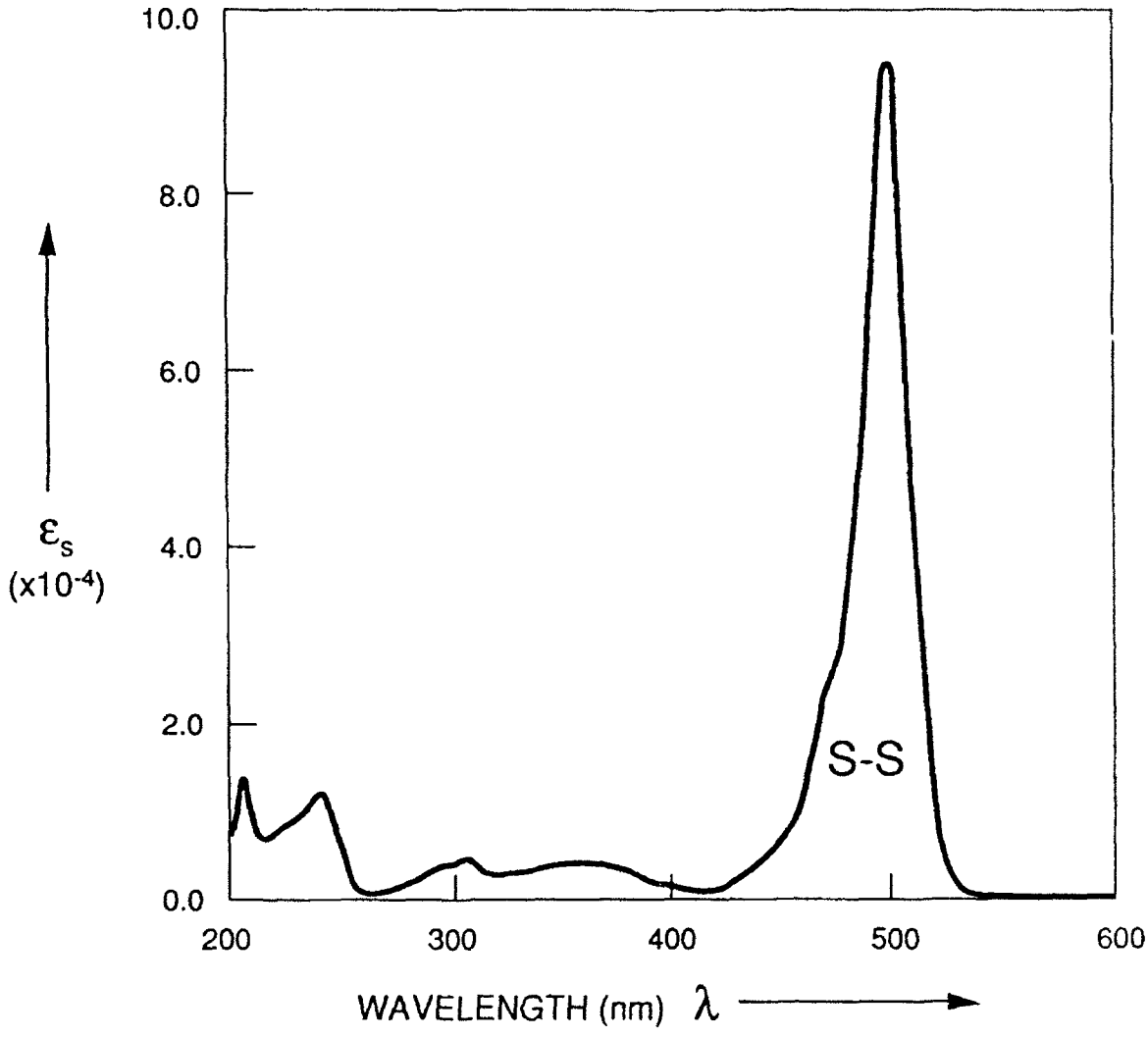
10.0
8.0
6.0
4.0
2.0
0.0
ε_s
(x10^{-4})
S-S
200
300
400
500
600
WAVELENGTH (nm) λ

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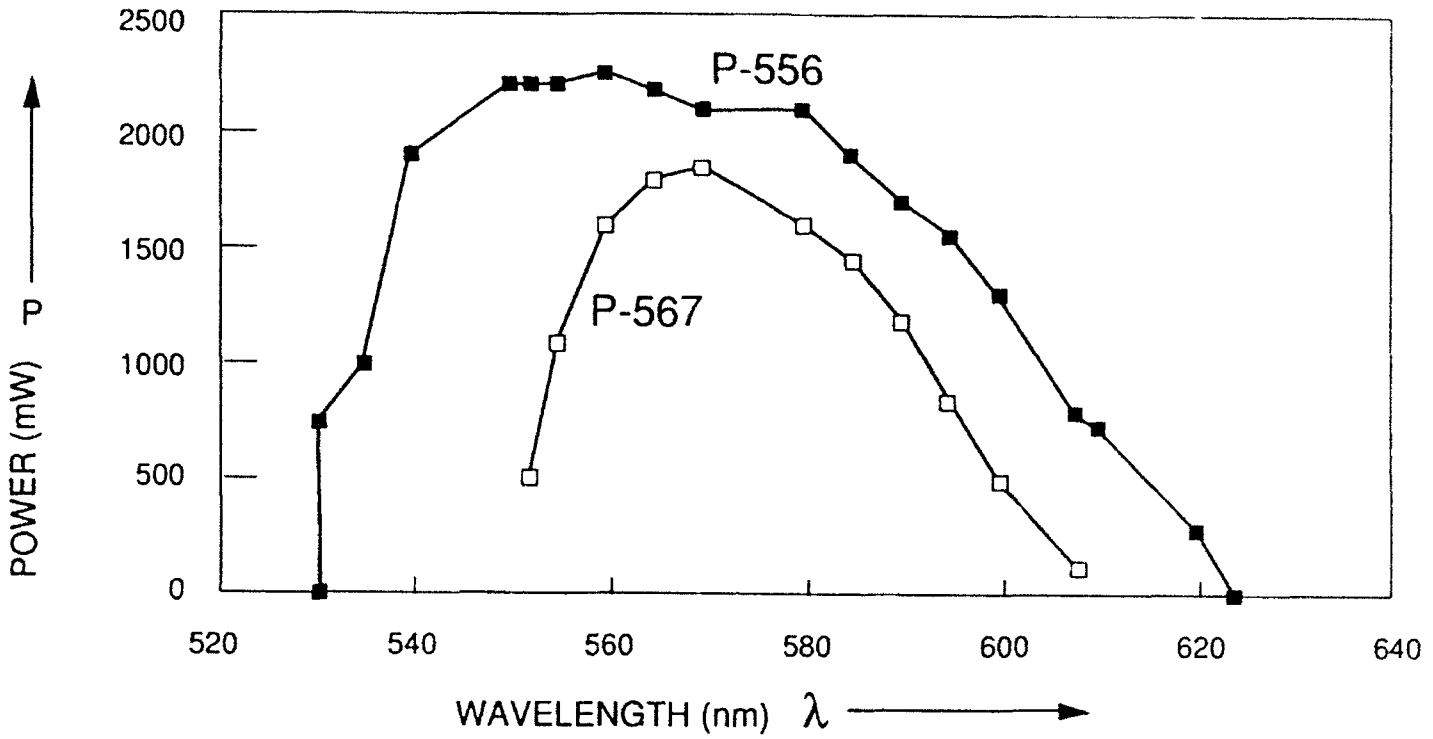
Figure 2

Tuning curves of the pyrromethene-BF_2 complexes P-556 and P-567.


2500
2000
1500
1000
500
0
POWER (mW) P
P-556
P-567
520
540
560
580
600
620
640
WAVELENGTH (nm) λ

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